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Pin Wire Coating Trip Report

G.P. Spellman

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LAWRENCE LIVERMORE NATIONAL LABORATORY

University of California

Plastics and Advanced Composites Group

P.O. Box 808, L-338, Livermore, CA 94551

Phone: (925) 422-7118 FAX: (925) 423-1572

Memo

To: Jim Janzen
From: Gordon Spellman
Date: 3/3/04
Re: Pin wire coating, trip report

A meeting to discuss the current pin wire coating problems was held at the Reynolds plant in Los Angeles on 2MAR04. The attendance list for Reynolds personnel is attached. There was an initial presentation which gave a brief history and the current status of pin wire coating at Reynolds. There was a presentation by Lori Primus on the requirements and issues for the coating. There was a presentation by Jim Smith of LANL on the chemistry and to some extent process development done to date. There was a long session covering what steps should be taken in the short term and, to a lesser extent, the long term.

The coating currently being used is a blend of two polymers, polyethersulfone and polyparabanic acid (PPA) and some TiO₂ filler. This system was accepted and put into production when the pin wire coating was outsourced to another company in 1974. When that company no longer was interested, the wire coating was brought in-house to Reynolds. At that time polyparabanic acid was actually a commercial product available from Exxon under the trade name Tradlon. However, it appears that the material used at Reynolds was synthesized locally. Also, it appears that a single large batch was synthesized in that time period and used up to 1997 when the supply ran out. Coincidentally the last batch of wires made with the old material actually had performance problems.

The reason for the inclusion of TiO₂ is not known although it does act as a rheological thickener. However, a more controlled thickening can be obtained with materials such as fumed silica. This material would have less likelihood of causing point imperfections in the coatings. Also, the mixing technique being used for all stages of the process is a relatively low shear ball mill process and I recommend a high shear process such as a three roll paint mill, at least for the final mixing. Since solvent is added to the powder at Reynolds, it may be that they need to have the paint mill there.

The coating process is relatively straight forward and I will not attempt to describe it here in detail. A solution of the two polymers in DMF or NMP is used as the coating medium. There is a drying process, but no reactions are known to occur during this process. The dried wire is slide through a sizing gauge and if it passes it is checked for dielectric strength by sliding the wire through a solution of ammonium citrate (possibly ammonium lactate).

There does seem to be a reasonable chance that pulling the wire through the sizing gauge could cause damage that would then show up in the dielectric test. An experiment to evaluate this is planned.

The primary cause of rejection, as I understand it, is failure at the dielectric test. However, some wires may be lost at the sizing station. What should really be kept clear here is that there have been significant rates of rejection throughout the history of pin wire production. The losses are higher with the thinner gauge wire used by LANL, 6 and 9 mil, versus the 10 mil wire used by LLNL. At this time there is also new concern over surface roughness and possibly micro-cracking at the surface. However, this is not a direct cause of rejection.

Incidentally, there was a step after the dielectric check in which the wire was coiled prior to final cleaning. This could possibly be a source of failure due to the abrasion between the coiled wires. Since the wire is not checked again this procedure should be stopped and will be. The wire will now be handled in straight sections for all processing, shipping, and storage after the dielectric check. This needs to be added to LLNL specs also.

Somewhat complicating the issue at this time is the recent introduction of a bending and thermal shock test as a new QA requirement. It was quickly proven that the thermal shock "test" actually caused damage and it was abandoned. However the bending test, coiling the complete wire around a 1 1/4 in diameter spool, was left in place. I believe this is a problematic test and unless the actual reason for implementing it can be found it should be dropped. I think the consensus was that it will be dropped for the short term although the reasoning behind the test will be elucidated.

There are numerous ideas of what experiments need to be run in order to 1) get good product as soon as possible, 2) understand the process better, and 3) develop a better material and/or process. These should be outlined in a report for Lori Primus. One area I was especially concerned with was the cleanliness and quality of the phosphate treated wire. It turns out that there is readily removable residue on the wire just prior to coating. This could lead to poor adhesion. A new procedure will include cleaning the wire until no residue is noticeable on a swipe with a white tissue.

One thing I volunteered to do was to look at the contemporary wire coating materials. The two polymers being used are normally not used for wire coating but for dielectric films. Both are high temperature polymers and that may or may not have been the reason to choose them at the time. Since the rationale for choosing the materials is unknown and the choice was made 30 years ago it seems logical to review what else might work better at this time. LANL has been also thinking of using heat shrink jacketing in place of coatings. I know of no commercial heat shrink that could do this job, but it is an appealing approach.

The polyethersulfone is a purchased product and thus needs only to be selected based on material requirements. The PPA is being synthesized at LANL and there has been some difficulty in controlling product properties. One suggestion is to contract the synthesis to a commercial vendor. As far as I can tell there is no longer any vendor for PPA. Nitto Chemical Industries made a product in the early 90's after Exxon abandoned production. I am trying to trace down if there is any manufacturer still in this business.

Since there has always been a significant rejection rate at Reynolds, especially for the thinner wire, LLNL's wire production may not be as difficult. However, if a significant portion of a product is failing to pass QA then one must assume that the possibility exists that an even larger portion is marginal. Since we rarely see a short in the final assembly, it may be that the test is too severe. On the other hand, if failures are associated with the sizing gauge, then it may be a very non-Gaussian distribution of defects at the dielectric test station.

For the LLNL needs it appears we have a good chance of receiving good wire with only the improvements agreed upon at the meeting. I suggested to LANL that they might consider allowing a slightly thicker coating and using slightly larger holes, or using smaller wire and thicker coating with the same holes. The same could hold true for LLNL if there is a production problem; we could go to 9 mil wire with a thicker coating allowance.

It appears that the pin wire coating process has always had some technical difficulties, especially in the finer gauges. The material system being used is not well understood as to reason for its use or processing properties. Wire can be made successfully at this time, albeit with a high rejection rate and therefore cost. There are new QA concerns and if these become necessary to implement the probability of successfully producing good wire will probably drop in the near term. New materials should be evaluated and commercially well known materials would be preferred. Some process improvements have been implemented and, as production continues, process data is being gathered and special tests are proceeding.

Gordon P. Spellman
Group Leader
Plastics and Advanced Composites
Lawrence Livermore National Laboratory
P.O. Box 808, MS L-338
Livermore, CA 94551
Ph: 925-422-7118
FAX: 925-423-1572
E-mail: spellman1@llnl.gov

**Hydrodynamic Applications
Group (DX-3)**
Dynamic Experimentation
Division (DX)

Mailstop P940
Los Alamos, NM 87545
Phone: (505) 665-4794
Fax: (505) 665-3359
Email: lorip@lanl.gov

Lori E. Primas, Ph.D.
Team Leader

Operated by the University of California
for DOE/NNSA



ESA-DO
Experimental Component Fabrication

Mailstop P917
Los Alamos, NM 87545
Phone: (505) 667-8032
Fax: (505) 667-1139
Email: milewski@lanl.gov

John O. Milewski
Program Manager

Operated by the University of California
for DOE/NNSA



REYNOLDS INDUSTRIES INCORPORATED

FABIO R. SANTOS
Engineering Supervisor

E-mail: fsantos@reynoldsindustries.com
www.reynoldsindustries.com

CORPORATE OFFICE
5005 McConnell Ave.
Los Angeles, CA 90066-6734
Tel: (310) 823-5491 ext. 249
Fax: (310) 822-8046

ARTHUR ALVES
Sales Engineer

E-mail: sales@reynoldsindustries.com
www.reynoldsindustries.com

CORPORATE OFFICE
5005 McConnell Ave.
Los Angeles, CA 90066-6734
Tel: (310) 823-5491 ext. 482
Fax: (310) 822-8046

REYNOLDS INDUSTRIES INCORPORATED

S. W. (STEVE) GOOD
Senior Staff Engineer
Electro-Mechanical Products

E-mail: sgood@reynoldsindustries.com
www.reynoldsindustries.com

CORPORATE OFFICES
5005 McConnell Ave.
Los Angeles, CA 90066-6734
Tel: (310) 823-5491 ext. 250
Fax: (310) 822-8046

JACK KORBEL
Vice President/Manager
Electrocal Connector Products Division
E-mail: jkorbel@reynoldsindustries.com

CORPORATE OFFICE
5005 McConnell Ave.
Los Angeles, CA 90066-6734
Tel: (310) 823-5491 ext. 260
Fax: (310) 822-6815

REYNOLDS INDUSTRIES INCORPORATED

PATRICK DOHERTY
Manufacturing Engineering Supervisor

E-mail: pdoherty@reynoldsindustries.com
www.reynoldsindustries.com

CORPORATE OFFICE
5005 McConnell Ave.
Los Angeles, CA 90066-6734
Tel: (310) 823-5491 ext. 233
Fax: (310) 822-6815

ARTHUR ALVES
Sales Engineer

E-mail: sales@reynoldsindustries.com
www.reynoldsindustries.com

CORPORATE OFFICE
5005 McConnell Ave.
Los Angeles, CA 90066-6734
Tel: (310) 823-5491 ext. 452
Fax: (310) 822-8046

REYNOLDS INDUSTRIES INCORPORATED

SAL ABTAHI
Supervisor
Materials & Process
Engineering

CORPORATE OFFICE
5005 McConnell Ave.
Los Angeles, CA 90066-6734
Tel: (310) 823-5491 ext. 272
Fax: (310) 822-6815